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THE POTATO ASSOCIATION OF AMERICA

LANCASTER, PA. NEW BRUNSWICK, N. J.

CULTIVATION AND SPRAYING

A few years ago efficiency in the cultivation of the potato crop was frequently measured by the number of cultivations. Too often also these were deep and close to the plant, resulting in more injury than benefit to the crop. We know now that efficiency in potato cultivation is not a question of the number of times the operation is performed but rather when and how it is done. The successful potato growers have come to depend to a greater extent on the weeder in the early season. They realize that when they have accomplished weed control they can expect little else. The idea that soil moisture is conserved by frequent cultivations is hardly tenable in view of the experimental evidence on this point.

Not only have our ideas concerning cultivation been changed as the result of experiments by workers in our Agricultural Experiment Stations but it is clear from recent results that we must likewise make some adjustments in our notions concerning the best methods to adopt for spraying the crop.

For many years, for example, it was held that Bordeaux mixture prepared with hydrated lime was not effective. Results of experiments in New York, New Jersey, Ohio and other states clearly show that Bordeaux mixture made from hydrated lime is as effective as that made from stone lime. It was generally held also that home-made Bordeaux mixture excelled the commercial product. While this was no doubt true a few years ago, at the present time there are commercial Bordeaux mixtures which are apparently as effective as those made on the farm.

Many potato growers still believe that it is advisable to use large amounts of lime in making Bordeaux mixture. These men should read the article by Dr. Blodgett and his associates in this issue of the American Potato Journal. Their results indicate that this as well as some other of our earlier ideas need be modified.

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NEW DEVELOPMENTS IN POTATO SPRAYING

F. M. BLODGETT, E. O. MADER, O. D. BURKE AND R. B. McCORMACK

We have been conducting spraying experiments in New York State for four years in some localities and for three in others. Some of these have been located up-state mostly on Rural varieties of potatoes and some on Long Island with Green Mountain potatoes.

In the present report an attempt is made to state some of the more important general results and to compare the results in these different localities. Much of the detail will of necessity be omitted in such a treatment. This detail though often interesting and of use in interpreting the results of the experiments must be left for more elaborate accounts.

One of the first things we sought to determine was the effect of spraying pressure in controlling diseases and insects and increasing yields of potatoes. Our series of experiments is now more extensive bearing on this point than any other. From the first, however, we recognized that in changing the pressure on a spraying machine we were really changing several factors. We were changing the amount of material applied and also its distribution. So our experiments were arranged with a view of at least partially separating these factors. Thus in comparing spraying at 200 and 400 pounds pressure, we used two sizes of orifices in the spraying nozzles so chosen that we could compare spraying at these two pressures using the same size of nozzle orifice and another comparison in which the same amount of material was applied at the two pressures. In most of the experiments three pressures were used with two sizes of nozzle orifices at each pressure. The plots in these experiments consisted of replicated sprayer strips. Check plots were sprayed with calcium arsenate only when required to control the potato beetle. These complications together with some variations in the arrangements and practices at the different places make it somewhat difficult to clearly explain the results.

If we first try to summarize the total effect of increasing the pressure, table 1, this summary may conceal almost as much as it makes clear but will serve as a starting point. Other figures will present the same material arranged in different ways to bring out the effect of factors lumped together in this first table. An inspection of table 1 serves to bring out some points, however. There were consistent gains

TABLE 1.—*Pressure spraying experiments 1929–1932*

Place	No. experiments	Average yield unsprayed	200 lbs. pressure over unsprayed		400 lbs. pressure over 200 lbs. pressure		600 lbs. pressure over 400 lbs. pressure	
			No. comparisons	Gain in yield	No. comparisons	Gain in yield	No. comparisons	Gain in yield
Pittsford	4	220.3	64	41.0 ± 5.7	107	30.1 ± 3.6	87	4.4 ± 5.9
Riverhead	2	249.9	64	33.1 ± 3.4	64	5.0 ± 4.1	64	−16.8 ± 3.4
Sagaponack	3	271.8	112	57.8 ± 5.2	100	7.3 ± 6.8	36	5.8 ± 17.9
Batavia and Western New York (Coop. expt.)		180.1	58	28.5 ± 13.7	121	6.1 ± 3.0	.....	.....
Average			298	43.2 ± 4.1	392	12.8 ± 3.3	187	− 2.6 ± 4.9

in yield of sprayed plots over unsprayed at all these places although blight was present only at Sagaponack.

The main object of the experiments, however, was a comparison between different spraying pressures. If we look then first at the average gain in yield for spraying at 400 pounds pressure over 200 pounds pressure at Pittsford we find it is about 30 bushels per acre with a standard error of 3.6 bushels indicating a highly significant difference. This difference is large enough so that there can be no doubt that this kind of spraying pays under the conditions at Pittsford. Also in each of the 8 nozzle combinations in 5 experiments in the 4 years at Pittsford which are averaged together in this table, a significant gain in yield was obtained by increasing the pressure from 200 to 400 pounds.

The results with Green Mountain potatoes at Riverhead and Sagaponack on Long Island at the same pressures, table 1, are quite different. The average gain in yield for spraying, at 400 over 200 pounds pressure was 5 bushels in one place and 7.3 bushels in the other and neither is apparently significant. If we were to look back of these averages at the results of the individual experiments, we find the results were quite variable, under some conditions gains, and under others losses by increasing the pressure from 200 to 400 pounds.

Further increasing the pressure from 400 to 600 pounds has given rather variable results even at Pittsford, the average gain being 4.4 bushels per acre with a standard error of 5.9 bushels indicating that this small average gain is not dependable. It may be said, however, that if the results with the smallest size nozzle orifice are considered, there is a consistent gain for this increase of pressure for the experiments at Pittsford, as shown more fully in figure 1. At Riverhead there is shown a consistent and significant decrease in yield for spraying at 600 pounds pressure as compared with 400. Also at Sagaponack no encouragement was found for this extreme pressure.

These same results have been rearranged in figure 1 in order to show a little more clearly the effect of the use of different sizes of nozzles at these different pressures. Pressures are plotted as abscissas and gains in yield, in bushels per acre, over the unsprayed plots as ordinates. Solid black lines connect the points at different pressures where the spraying was done with the same nozzles without any change either in size of nozzle orifice or in number or arrangement of nozzles. Dotted lines connect points at different pressures but where the nozzle orifice size was varied so that the same amount of spray was applied. Dot dash lines are used to connect certain points at different pressures between which neither of the above relations hold. Some of the lines are starred to indicate comparisons in which the differences in yields are apparently significant.

From this diagram, it is obvious almost at a glance that the results for the four years at Pittsford have been very consistent. From a

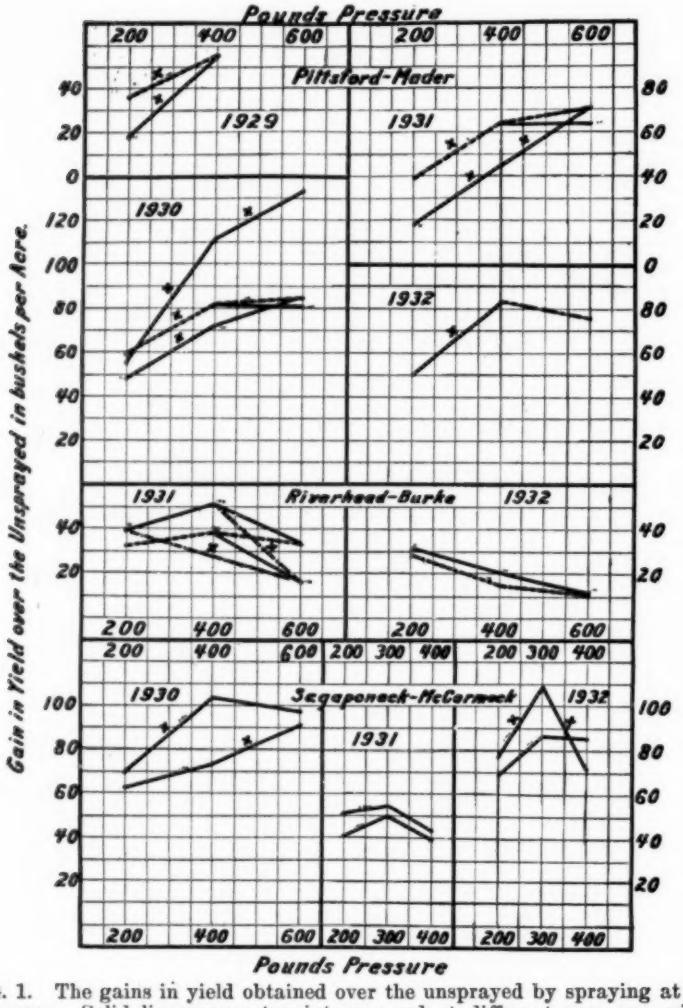

FIG. 1. The gains in yield obtained over the unsprayed by spraying at different pressures. Solid lines connect points sprayed at different pressures with the same size nozzle orifice. The dotted lines connect points where the same number of gallons per acre were applied. Lines connecting points that seemed to be significantly different in yield are marked with an "*x*."

study of the results at Pittsford it is also apparent that part of the increase in yield obtained by spraying at higher pressures is due to the increased amounts of spray applied. Or to state it another way, a considerable part of the increase can be secured by applying the larger amount of spray at the lower pressure. And apparently about the maximum increase in yield can be obtained without waste of labor and material by spraying with liberal amounts of material at 400 pounds pressure.

There was the suggestion in both 1930 and 1931 yields, that when we used the larger nozzle size at 600 pounds pressure we were over spraying the potatoes.

Now if the results at Riverhead with Green Mountain in 1931 are compared with those at Pittsford on Rurals, a quite different relation is found in that higher yields were consistently obtained with the lighter applications.

Both at Riverhead and at Sagaponack there is evident a tendency for the heaviest applications at the highest pressures to give less than the maximum increase in yield.

Because of the apparent inconsistency between the results at Pittsford and on Long Island, the differences in these experiments were scrutinized for any reasonable explanation which might form the basis for further experimental work. The main difference was that on the Island we were making a larger number of applications of spray materials during the season; at Pittsford 6 to 8 applications, on the Island 10 to 13. This would naturally affect the total amount of copper accumulating on the plant. At the end of the 1931 season, a summary chart was made, based on the total amount of copper sulfate applied under like conditions. A study of this chart seemed to indicate that the total amount of copper sulfate applied was at least an important factor and perhaps would help explain the results already obtained.

Accordingly our experiments were rearranged to test this point more directly in 1932. We have now made a new summary of the accumulated evidence at the different places, fig. 2, bearing on this point. Experiments are included in which the total amount of copper sulphate applied in the form of bordeaux was varied by changing the concentration of mixtures, the frequency of application, and the number of gallons per acre applied per application. From this figure it is apparent that the influence of the total amount of copper sulphate applied was more marked at Pittsford than at points on the Island. The yields at Pittsford increased to a maximum as the amount of copper sulfate applied was increased to about 75 to 80 pounds per acre per season and fell off significantly when we went much above this amount.

While at Riverhead and Sagaponack the results of individual experiments are not conclusive, when considered altogether they seem to indicate that the amount of copper necessary to give maximum yields may be considerably lower than at Pittsford.

One other factor that has been tested in field experiments to some extent has been the influence of different kinds of lime used in making Bordeaux. It was recognized from the first that the differences to be found would probably not be large because of the excess of lime represented by the formula commonly used. In these experiments we have compared hydrated lime made from high calcium rock, hydrated lime

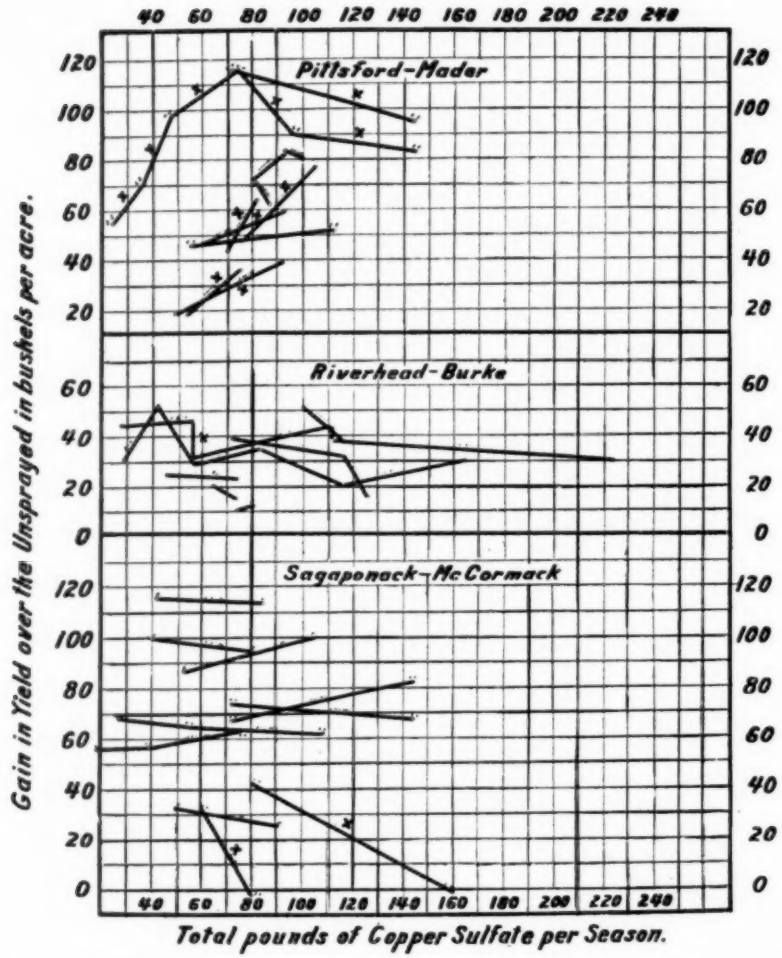

FIG. 2. The effect of variations in the total amount of copper sulfate applied during the season on the gains in yield over the unsprayed. Lines connect points sprayed at the same pressure but where the total amount of copper sulfate was varied either by varying the concentration, the number of gallons applied per acre per application or the frequency of the applications.

with a high magnesium content (about 30%) and stone lime. The results, table 2, have shown relatively small and variable differences but when we accumulated the results to the end of 1931 of all our experiments we found a relatively small but apparently significant difference in favor of the high magnesium lime as compared with the high calcium lime. Since we were advised that the magnesium in this lime was quite insoluble and probably did not take any part in the formation of the Bordeaux, we selected as a probable explanation of our results the

TABLE 2.—*Comparison of Bordeaux made with different kinds of lime and soda 1930–1931*

Yield of checks	Average gain in yield in bushels per acre by spraying with Bordeaux									
	No.	Made with hydrated lime over checks	No.	Made with finishing lime over hydrated	No.	Made with stone over hydrated	No.	Made with hydrated over soda	No.	Made with coarse over fine hydrated
				Experiments at Pittsford by Mader						
204.2	4	85.4	18	8.2	18	17.3	.....	.....	.....	.....
208.7	4	71.9	.....	.....	12	10.1	.....	.....	.....	.....
171.4	3	15.1	12	12.7	12	8.7	.....	.....	.....	.....
163.7	3	94.2	12	24.7	12	1.2	.....	.....	.....	.....
				Experiments at Sagaponack by McCormack						
261.1	24	114.6	.....	.....	48	−4.6	48	50.8	.....	.....
277.5	24	23.1	.....	.....	.....	.....	24	35.7	24	3.6
							24	45.5	24	−5.0
				Experiments at Riverhead by Burke						
297.5	24	15.1	48	16.0	.....	.....	.....	.....	48	14.2
				Experiments at Batavia by Taylor						
87.0	2	43.6	9	−8.2	.....	.....	.....	.....	.....	.....
224.1	16	58.8	16	2.8	.....	.....	.....	.....	16	6.4
	104	54.4 ± 14.0	115	11.6 ± 3.7	102	3.24 ± 4.3	96	45.7 ± 4.4	112	6.7 ± 4.3

hypothesis that the ratio of lime to copper in our formulae was too high and that when we used a high magnesium lime we were using in effect a lower ratio of lime to copper. Accordingly during the past season we added experiments in which the ratio of copper to lime was varied by varying the amount of lime. The results of these experiments, fig. 3, indicate that the explanation selected was at least a sufficient one. While the differences shown at Riverhead seem not to be significant those at Sagaponack and Pittsford are. Particularly at Pittsford the number of replications and uniformity of the field were sufficient so that the differences in yield between each successive ratio tried are significant. This experiment shows quite clearly that as the amount of lime in the mixture was decreased the yield increased.

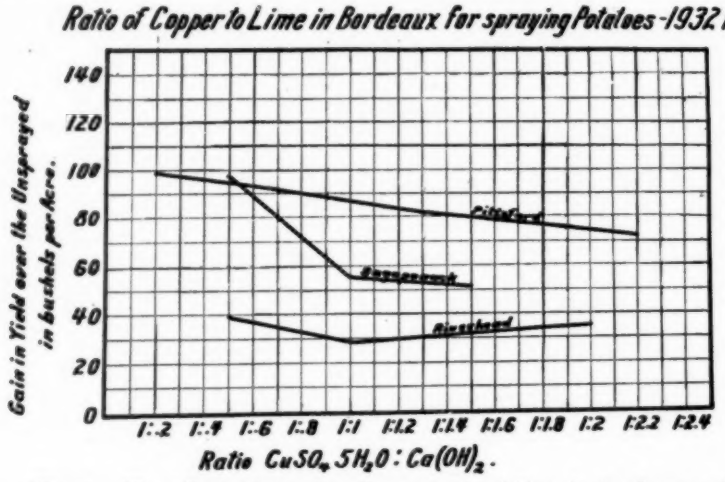

FIG. 3. The effect of varying the amount of lime in bordeaux mixture on gains in yields of potatoes over the unsprayed in three experiments. The amount of copper remained constant.

Another item which may be of interest is a summary of the amount of injury caused by the spray machines. As we used 6 row sprayers, the outside rows were not injured (Row 1 in the table), the second rows from the outside (Row 2 in the table) had injury on one side by horses and wheels, and the two inside rows (Row 3 in the table) had, in addition to any injury by horses and wheels, any additional injury caused by underslung tanks. As the yields were taken on each row separately in many of our experiments we could with little trouble summarize the data (table 3) to show the comparative yields in the sprayer strip. The summary shows the average wheel injury in our experiments was about 15 bushels per acre on the four center rows but varies considerably under the conditions at different places.

One other comparison on which considerable data have accumu-

lated in one locality is between one and three nozzles per row. At this place the sprayer was equipped with 3 nozzles per row on three rows on one side and 1 nozzle per row on each of three rows on the other side. Where one nozzle per row was used the orifice was enlarged so that as many gallons per acre were applied as with 3 nozzles per row on the other side of the sprayer. The sprayer was used equipped in this way for two years in a number of experiments until 342 comparisons were available for averaging. A summary of these (table 4) showed there was no significant difference in yield. Obviously from

TABLE 3.—*Summary of injury due to spraying*

Row No. 1. No wheel injury
Row No. 2. Injured by wheels and horses
Row No. 3. Injured by wheels, horses, and tank

Locality	Year	Number of comparisons	Average yields in bushels per acre		
			Row No. 1	Row No. 2	Row No. 3
Pittsford	1930	108	306.2	291.0	.....
Riverhead	1930	256	247.0	236.9	238.0
"	1931	240	320.4	302.4	304.4
Sagaponack	1930	116	378.1	364.5	358.2
"	1931	176	317.4	291.3	291.3
Batavia	1930	16	151.8	143.6	.....
Hicksville	1930	160	266.1	258.8	253.1

Average differences

	Number comparisons	
Gain Row 1 over Row 2	1072	15.0 ± 2.5
Gain Row 2 over Row 3	948	.9 ± 1.6

what has been said the outcome might have been different if all of the nozzles had the same capacity.

Summary

Maximum yields were obtained on Rural potatoes in upstate New York over a period of four years by spraying at 400 pounds pressure and using a total of 75 to 80 pounds of copper sulphate per acre per season in the form of Bordeaux. Apparently less copper sulphate per acre per season is required on Long Island to get the maximum yield.

As the amount of lime in the Bordeaux was decreased better yields were obtained. A ratio of 5 pounds copper sulphate to 2½ pounds of hydrated lime to 50 gallons of water is believed to be a safe recommendation.

TABLE 4.—*One versus three nozzles per row. As much material applied with one as with three nozzles*

Experiment	No. plots	Gallons per acre	Yields in bushels per acre			
			One large nozzle per row	Difference in favor three nozzles	Three small nozzles per row	Unsprayed
1930						
Pressure 200	18	80	343.0	4.7	347.7	280.4
" 400	18	105	353.8	30.2	384.0	
" 600	18	125–140	377.5	−5.6	371.9	
4–4–50	24	100	380.6	5.6	386.2	313.0
8–8–50	24	100	395.8	−14.4	381.4	
1931						
Fine Hyd.	24	100	302.3	−3.4	298.9	277.5
Coarse Hyd.	24	100	305.9	−15.4	293.9	
Soda	24	100	266.6	−13.2	253.4	
4–4–50 (400)	24	100	301.5	− .8	300.7	268.3
4–4–50 (200)	24	100	300.9	9.9	310.8	
Weekly	24	100	296.2	− .4	295.8	271.0
Biweekly	24	100	303.5	− .3	303.2	
Pressure 200	24	175	316.7	9.7	326.4	276.0
" 300	24	85	325.8	5.0	330.8	
" 400	24	100	315.2	3.9	319.1	
	342		323.98	.81 ± 2.74*	324.79	281.06

* Standard error.

The total amount of copper applied is indicated as an important factor in success in potato spraying whether effected by concentration of mixture, gallons per acre applied, number of applications, or number of nozzles per row. The optimum amounts vary for different varieties of potatoes or different conditions.

The sprayers used were shown to cause a measurable loss in yield. The desirability of reducing this to a minimum is indicated.

FURTHER STUDIES OF THE ORIGIN OF RUSSETING IN THE POTATO

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The character of russet skin in the potato is one not only of scientific interest but also of considerable practical importance. In most varieties the russeting is accompanied by a thickened skin which serves as a

protection to the tuber and prevents much bruising in the handling of the crop. Studies have also shown that russeting is generally associated with resistance to the common potato scab (*Actinomyces scabies*).

In a previous paper Clark (2) reported the results obtained in 1929 and 1930 in studies of the origin by mutation of certain potato varieties. Since the material for the tests of one of these varieties, the Russet Burbank, was limited to a small number of plants and only negative results were obtained it was deemed advisable to continue the studies on a more extensive scale.

In 1931, 100 tubers were cut in halves and the eyes removed from one series, the untreated series of corresponding halves being used as checks. The methods of preparing and planting the seed tubers were the same as those employed the preceding year.

The germination of the sets from which the eyes had been removed was delayed considerably beyond the time of the germination on the check rows, consequently the growing season of the treated series was shortened to such an extent that the tubers were small and immature, thus making it impossible to determine with certainty the extent of russeting. For the purpose of growing the two series under the same conditions with respect to length of season, so that an accurate comparison of the amount of russeting could be made, one tuber was saved from each hill and planted the following season. At the time of harvest, in 1932, no difference could be seen in the russeting of the tubers of the treated and untreated series. To verify the general observations the tubers of approximately one bushel of each series were counted. The tubers were separated into two classes according to the relative amount of russeting. In one class the russeting was well defined over a considerable part of the tuber, while in the other the russeting was slight and confined to the apical end of the tuber. The distributions, based on the degree of russeting in the two series, are given in the following tabulation:

	Eyes removed		Untreated	
	Russeting well distributed	Little russeting	Russeting well distributed	Little russeting
Number of tubers	216	38	201	35
Per cent of tubers	85.0	15.0	85.2	14.8

Asseyeva (1) has described three types of periclinal chimeras: (1) the epidermal, in which only the epidermis is changed; (2) the subepidermal, in which the change occurs in the subepidermal layer; and (3) the dichlamydeous, which involves changes in both these layers.

The effect on the succeeding crop following the removal of the eyes differs somewhat with the three types. The epidermal type reverts to the normal form; the subepidermal becomes changed, partly to the normal form and partly to dichlamydes; the dichlamydes revert to the normal though the percentage of reversions may be small, in fact, some instances have been cited in which no changes have been observed.

The data obtained from the Russet Burbank experiments tabulated above show no evidence of the origin of this variety as a periclinal chimera of any of the three types. Since, however, instances have been known, though rare, in which the removal of the eyes from dichlamydes did not disclose the normal type the evidence does not definitely preclude the possibility of this type of mutation.

The relatively high percentage of tubers with little russeting in both series is attributed to the action of soil and climatic conditions. As grown in northern Maine the russeting of the tubers of this variety is not so complete as it is in some other sections of the country. Apparently the degree of russeting is influenced by environmental conditions.

Efforts have been made to secure a seed progeny of the Russet Burbank but because of the difficulty involved in crossing this variety, due to the scarcity of flowers, only a few seeds have been secured. In 1932 seven plants were obtained from a cross between this variety and Katahdin, two of which produced russet tubers. The russet skin character of the Russet Burbank would be expected to appear in this progeny if it were the result of the action of either a single dominant factor or of complementary factors, one of which may or may not be present in the other parent.

TABLE 1.—*Segregations for russet and white skinned tubers, respectfully, obtained from crosses and from inbred and naturally fertilized progenies*

Parents	Number of seedlings producing	
	Russet tubers	White tubers
Russet Burbank × Katahdin	2	5
Rural New Yorker × "	76	517
S. 42672 × "	1	2,257
S. 44537 × "	16	30
S. 44537, inbred	2	2
Katahdin, naturally fertilized	0	483

In a cross between Rural New Yorker and Katahdin, 76 of the progeny produced russet tubers. (See Table 1.) Since both parents are white tubered varieties it must be assumed that the russet skinned segregations are the result of the action of complementary factors.

According to this assumption, in the cross Russet Burbank × Katahdin, to which reference has previously been made, a factor, or factors, for russeting most necessarily be carried by the Russet Burbank, as well as the Katahdin, thus indicating that the Russet Burbank may have originated as a seedling rather than as a somatic mutation.

The results obtained from other crosses and from self and open pollinations may be of interest as bearing on the origin of russeting. In a progeny of 2258 seedlings obtained by crossing S.42672 with Katahdin, both white tubered varieties, there appeared one with tubers very heavily russeted (S.44537). It is difficult to account for this ratio by the normal process of segregation, therefore it is concluded that this is a mutant, having arisen by mutation of the factor which is complementary to the one assumed to be carried by Katahdin. This is not an epidermal periclinal chimera since the factors for russet skin are transmitted through the germ cells, as is shown by the occurrence of russet skinned seedlings in the progenies of this variety when crossed with Katahdin and when inbred. (Table 1.)

No russet skinned tubers appeared in the progeny of Katahdin naturally fertilized which is the expected behavior of a variety carrying only one factor of a complementary series.

SUMMARY

The results obtained from the removal of the eyes of the Russet Burbank showed no indication of the origin of this variety by mutation though the possibility of its origin as a dichlamyde mutant was not entirely eliminated.

Breeding tests in which the factors for russet skin were transmitted through the germ cells suggest that this variety may be of seedling origin.

The results of crosses indicate that in the material studied the russet skin of the tubers was the result of the action of complementary factors.

In the seedling No. 44537 the russet skin character apparently is due to a mutation. Progeny tests show that it is a gene mutation.

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CULTIVATING POTATOES: HOW AND HOW MUCH?

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The proper cultivation of potatoes is an art dependent on good judgment and a knowledge of the general principles involved, rather

than a science which can be reduced to set rules. From the previous generation of soil scientists we inherited a number of beautiful theories, such as the conservation of soil moisture by a surface mulch, stimulation of soil bacteria and nitrification through the aeration of the soil, and so forth. These could be demonstrated in the laboratory, but most of them somehow failed to prove out in field experiments, which are the real and final test of any theory. In repeated experiments with corn, and more lately on Long Island with potatoes, cultivation has caused a decrease as often as an increase compared to plots where the weeds were simply scraped off with a hoe and the soil never stirred. Where the weeds were allowed to grow yields were naturally extremely low.

When all is said we come back to the original idea of cultivation; namely, that the primary object is to kill weeds. Some form of cultivation is, so far, the only economical means of weed killing devised. If weed growth is controlled, in the rows as well as between them, further stirring of the soil will apparently accomplish little, and often reduces the yield, though there is some evidence that in years of extreme drought, like 1930, it may be slightly beneficial.

Some one has suggested the term "birth control" for the killing of the first few crops of weeds, through the use of the harrow and weeder, before the potatoes are above ground. The time to kill weeds is while they are small and weak, not after they have become firmly established and deeply rooted. The spike harrow or weeder also gets over the ground much more rapidly than the row cultivator. Where the seed pieces are planted fairly deep the harrow can be run deep enough to thoroughly loosen the surface soil and can even be used after the potatoes are up with little or no damage. In 1928 the Pennsylvania 400 Bushel Club Members harrowed an average of 2.3 times, some as many as four times.

The first row cultivation may, and under some conditions should be, deep and fairly close in order to thoroughly loosen up the soil compacted between the rows in planting, and to allow heavy rains to penetrate rapidly. As soon as the roots begin to spread out, however, especial care should be taken to prevent root injury. Tearing off roots is a mutilation of the plant which will check and sometimes permanently injure its development. When good sized potatoes are cultivated closely or deeply, the whole field may sometimes be seen to wilt in the hot sun, even though the soil is not very dry. Such cultivation does more harm than it can possibly do good. Deep cultivation after the tubers are set might easily have been responsible for much of the stem end discoloration so prevalent in late potatoes during the past dry seasons.

The tendency to run the cultivation too deep is especially common where a tractor cultivator is used. The operator has plenty of power,

is often in a hurry, and the outfit runs more steadily with the rear shovels set deep, consequently the ground is often torn up deeply and roots broken regardless of consequences. When starting on the later cultivations, one should always stop and scrape the loose dirt away from behind the shovels next the row. The number of roots being torn loose will often be a surprise. A little adjustment may prevent most of the damage and the purpose of the cultivation still be equally well accomplished. If serious root pruning cannot be avoided, and if there are not many weeds to be killed, it may be better to stop cultivating altogether.

The tendency among the Pennsylvania 400 Bushel growers has been steadily toward *less* frequent row cultivation, along with *more* frequent use of the weeder and more harrowings before cultivation starts. In 1926 the average number of row cultivations was 5.8. By 1930 it had gradually been reduced to 2.8. In 1926 only 70 per cent of the 400 Bushel growers used a weeder and used it an average of 3.8 times. In 1929, 90 per cent used a weeder an average of 5.5 times. Some have tried to make a weeder serve for all cultivation, usually the soil between the rows must be broken up more deeply than the weeder will do it. If the weeder is used often enough, most weeds can be killed in the "birth" stage with comparatively shallow stirring of the soil. With rows averaging only about 32 inches, seed pieces only about 10 inches apart and with vigorous growth, the ground is soon so nearly covered that there is no need for the number of cultivations formerly thought essential.

Another debated point is as to whether potatoes should be ridged or hilled up. Practically all cultivation experiments show better yields from level cultivation, less moisture is lost by evaporation and the roots are less disturbed. If weeds in the row have been allowed to develop beyond the stage where the weeder will kill them, they may sometimes be smothered by ridging. Again, if there is danger of the tubers pushing out and getting sunburned, it may be well to throw some dirt to the row. In either case, ridging should be regarded as an evil which may or may not be necessary. There is much less excuse for ridging with late potatoes, which if planted well down in the ground will not set close enough to the surface for exposure to be serious. Ridged potatoes are doubtless easier to dig, but something is usually, if not always, sacrificed in yield to gain this advantage.

Serious and irreparable damage may also be done by cultivating when the soil is too wet. This is particularly true where tractors are used. Some growers who have attempted to do all cultural work with tractor power have been very much out of luck in a wet season.

When wet weather has prevented normal cultivation until weeds have attained some size, a set of sweeps will cut the weeds below the surface but need not be run deep enough to tear the potato roots

severely. Otherwise, deep and damaging cultivation will be necessary. Sweeps are also invaluable for the control of perennial weeds such as Canada thistle which will dodge past the ordinary shovel. The presence of many stones, of course, limits the practicality of sweeps.

EFFICIENCY FACTORS IN THE CULTIVATION OF POTATOES

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The primary function of cultivation, apparently, is weed control. Increase in potato yields resulting from the maintenance of a soil mulch to conserve soil moisture has been overemphasized. This has been shown by the results of recent experiments reported by the Cornell University[1] and the Pennsylvania[2] Experiment Stations. In both of these experiments running four to five years, plots receiving 3 to 5 cultivations yielded as well as plots cultivated 8 or more times. Similarly, plots in which the soil was never stirred and weeds were controlled by scraping or cutting yielded as well or better than the cultivated plots. The conclusion is that cultivation may be overdone, particularly during periods of drought, where weed control does not require it, and late in the season when tillage results in serious root damage.

COST OF CULTIVATION

The actual cost of cultivation should be measured not only in terms of man, horse and equipment labor required but also in terms of loss in yield resulting from root pruning and unnecessary drying out of the soil. This last named item of cost is seldom recognized by the grower because he has no means of knowing what it amounts to except as he refers to such experimental results as those mentioned.

Potato cost of production records were kept on 78 farms in western New York during the years 1927, 1928 and 1929. Cost items in growing, harvesting and storing and selling the crop were kept separately. On these farms, a total of 33.5 man hours and 34.8 horse hours were required to grow the crop. Detailed records of the labor required for each tillage operation on these farms are not available. Such records are available, however, from a study made by F. L. Underwood[3] on 120 farms in western New York in 1929. Following is a

[1] Thompson, H. C., Wessels, P. H., and Mills, H. S. Cultivation experiments with certain vegetable crops on Long Island. Cornell Univ. Agr. Exp. Sta. Bul. 521. 1931.

[2] Merkle, F. G., and Irvin, C. J. Some effects of intertillage on crops and soils. Pa. Agr. Exp. Sta. Bul. 272. 1931.

[3] Underwood, F. L. Factors affecting costs and returns in producing potatoes in New York in 1929. Cornell Univ. Unpublished Thesis (1931).

brief summary indicating the extent to which each of the common weed control operations was practiced:

TABLE 1.—*Weed Control in Potatoes on 120 Farms in Western New York in 1929* (From F. L. Underwood's Thesis)

Operation	Number of times	Total man labor per acre (hours)	Total horse labor per acre (hours)
Re-covering	0.4	0.5	1.1
Weeding	1.8	1.4	2.2
Cultivating	3.7	7.4	14.1
Hoeing & pulling weeds	0.6	2.2	none
Hilling	0.4	0.5	1.1
Totals	6.9	12.0	18.5

These figures indicate that growers in western New York go over their fields an average of about seven times to control weeds. They also show that a large proportion of growers do not re-cover their plants early in the season or depend on hoeing, weed pulling, or the use of a potato hiller to control weeds. However, in view of the results of the Cornell and Pennsylvania experiments many of these growers may not be justified in going over their fields as many as seven times during the season. Taking the above figures into account, it appears that on the average these five tillage operations involved 36 per cent of the total man hours and 53 per cent of the total horse hours required to grow the potato crop. Figuring man labor at 42.6 cents per hour and horse labor at 22.5 cents per hour, the average cost rate on these farms in 1929, the total cost per acre for these tillage operations amounted to $9.27, or about 11 per cent of the total growing cost. Whereas the average cost per acre per single operation was $1.34, the cost naturally would be lower for the use of the weeder and higher for all other operations. More frequent use of the weeder early in the season or until the plants are 8 to 10 inches high and less row cultivation is now recommended to growers throughout New York. This has been proven to be both cheaper and more effective than the present system of weed control.

RIDGE VERSUS LEVEL CULTURE

The factors which determine the degree of ridging practiced in a given region are mainly three: (1) seasonal rainfall, (2) soil type, and (3) depth of planting. Where rainfall is high, ridge culture provides runoff for surface water which might otherwise damage the crop. Where the soil is of heavy type, growers generally practice ridging to facilitate digging. Shallow planting necessitates a certain amount of ridging to keep the developing tubers covered and to control weeds. However, from the standpoint of yield, ridging can be and often is

overdone. One of the first experiments to compare ridge with level culture was that done by Stone[4] at the Cornell station during the five year period 1897–1901. Each year of the five, the same number of cultivations were given each set of plots. Even though the soil type was heavy silt loam, yields were in favor of level culture, every year the differences varying from 1 to 37 bushels and averaging 14 bushels per acre.

White[5] at the Maryland station during the years 1914–1916 compared yields from the shallow planted-high ridge system as practiced in Maine with those from level culture. Here the soil was of a "medium stiff loam." Every year the yields were higher under level culture, the differences varying from 2 to 44 bushels and averaging 17 bushels per acre. Similarly Woods[6] at the Maine Station in a four year experiment (1910–1913) compared deep planted-level culture, medium planted-medium ridge, and shallow planted-high ridge culture using two varieties in each case. In three years out of the four, the shallow planted-high ridge system gave the lowest average yields. Yet this was the system most commonly used in Maine up to that time.

In spite of the preponderance of experimental evidence against extreme ridge culture, it is still practiced by a majority of growers in most counties of New York outside of Long Island and a few of the drier areas in the western part of this state. Apparently, in the growers' minds, the advantages of easier digging from a ridge and less labor involved in shallow planting more than outweigh any possible increase in yield from level culture. Nevertheless growers having fairly level fields are being encouraged to plant by the furrow plant-shallow cover method. The objection that it is difficult to furrow four inches deep with the planter can be met by deeper plowing and fitting and by reversing the discs on the planter. By using the larger pair of discs on the front and the smaller pair on the rear of the planter, the seed piece will be covered shallow and left in a partially filled furrow. The advantages of this method are several. It results in deeper planting, quicker comeup, less sprout injury from rhizoctonia, easy weed control as the furrow is filled and eliminates any real necessity for ridge culture later on. This system of planting followed by frequent use of the weeder early in the season and level culture is on the increase in such low rainfall counties as Genesee and Monroe. It is recommended as the best method of conserving soil moisture and reducing the cost of weed control.

[4] Stone, J. L. Potato growing in New York. Cornell Univ. Agr. Exp. Sta. Bul. 228. 1905.

[5] White, Thomas H. Fertilizing and cultural experiments with Irish potatoes. Maryland Agr. Exp. Sta. Bul. 215. 1918.

[6] Woods, Chas. D. Potato studies. Maine Agr. Exp. Sta. Bul. 277. 1919.

RIDGING RELATED TO SUNBURN INJURY

Sunburn injury results in considerable loss to potato growers every year. Federal and state grading standards require that such tubers be eliminated from No. 1 grade. There has been some question as to whether high ridge culture results in more or fewer sunburned tubers than level culture. This factor was studied as a part of a tuber defect survey made by the New York State College of Agriculture at harvest time on 105 farms in 1931 and on 171 farms in 1932. Height of ridge in inches was determined in each field by laying a yardstick across two adjacent unharvested rows and measuring the height from the trough between the rows to the horizontal yardstick. In this way, height of ridging in 15 counties including Long Island was found to vary from 2 to 9 inches.

The percentage of sunburn injury was next determined in each field by careful examination of 100 freshly dug tubers. The relation of height of ridge to sunburn injury is summarized in table 2.

TABLE 2.—*Relation of Height of Ridge to Sunburn Injury on 258 New York Farms. (Average 1931–1932)*

Height of Ridge (inches)	Number	Per cent of farms	Sunburned tubers (per cent)
2.0–4.0	67	26.0	5.4
4.5–6.0	100	38.8	4.3
6.5–9.0	91	35.2	3.7
Total and average	258	100.0	4.4

Although ridging does not appear to have a large influence on the amount of sunburn injury, the study for both years showed consistently less injury in those fields ridged highest. In view of the fact that extreme ridging, applied when the plants are large and growing rapidly, usually results in loss of soil moisture, much root damage and ultimately reduced yields, it should be done only late in the season after the plants are nearly mature. If it appears necessary to ridge earlier in order to take care of surface water on the heavier soils, the ridge should be broad or the furrow narrow. Another suggestion is that deeper planting will result in the tubers forming at a lower level with a consequent reduction in sunburn injury.

CONCLUSIONS

Recent experiments indicate that it usually will pay best to cultivate potatoes only a sufficient number of times to control weeds efficiently. Frequent use of the weeder early in the season will eliminate much of the usual more expensive weed control operations later on. Labor costs for weed control alone on 1120 farms in western New York in

1929 amounted to about 11 per cent of the total cost of growing the crop. Experiments comparing yields from ridge and level culture have generally favored the latter. Deeper planting or the furrow plant-shallow cover method will eliminate much of the apparent necessity to resort to ridging as a means of late season weed control. A survey of practices on 258 New York farms indicated that sunburn injury is somewhat reduced by ridging. Unless the ridging is done after the plants are nearly mature, the ridge should be wide at the bottom and flat at the top. Finally, it can no longer be truthfully said that the best potato grower is the one who cultivates most often. Rather is he the grower who handles his weed problem with fewest cultivations and at lowest cost.

CROP AND MARKET NEWS

By early May, Florida had nearly finished harvesting its commercial crop of 1,870,00 bushels of potatoes, and the shipping season was beginning to wane. Output of Florida to late April was fully one-third heavier than to the same time last season, in keeping with the 30% increase of production this year. The lower Rio Grande Valley of Texas also reported a 40% gain in production, or a total commercial crop of 1,030,000 bushels. Movement from Texas was comparing very favorably with that of last season.

Considerable change has occurred this season in containers for Florida potatoes. The double-head barrel is still the most desirable package along the eastern seaboard, but farther west the 100-pound sacks are increasing in popularity, while cities in Ohio, Illinois, and Indiana are asking for the bushel crates. Practically all dealers loaded crates to fill special orders, and the local Growers Association at Hastings averaged about 15 carloads of crates per week since the beginning of the season. One manufacturing concern introduced a new type of wire-bound crate, which is lighter than the usual type. Reports indicate that this package has been well received in terminal markets. Many shippers who still use the barrel are using 100-pound sacks for the U. S. No. 2's.

Interesting developments are reported with respect to marketing of the summer crop farther north. Establishment of a central marketing agency for the handling of New Jersey's potato crop is being considered by growers and dealers, with a view to eliminating ruinous competition, New Jersey College of Agriculture has announced. The proposal for a central agency, in which all potato dealers will be represented, came from a committee appointed last fall by growers to effect improvements in the system of selling New Jersey potatoes. If this plan is adopted, it will mean that all prices for New Jersey potatoes will be quoted from one office.—*Bureau of Agricultural Eco-*

For four weeks from March 28 through April 24 the F. O. B. price for Florida potatoes was steadily maintained at $3.00 per barrel for U. S. No. 1, and 25 cents higher on warehouse packed, washed potatoes. No. 2's brought about $1.75 per barrel, with washed stock 25 cents higher. Florida suffered some very heavy rains from April 2 to April 15; on April 6, five inches fell in less than 24 hours. Late Blight was prevalent all season but dry weather from February 28 to April 1 checked its development. It spread rapidly, however, after April 3 and on April 18 nearly all vines were dead. Late Blight was the cause of much rot developing on the tubers. This decay, together with the fact that consignments to New York and Philadelphia were heavy during the week of heavy shipments, caused prices to decline to $2.50 per barrel F. O. B. on April 25.

The marketing agencies maintained a firm stand for four weeks and held prices to the higher levels. Had the growers cooperated to a larger extent in eliminating consignments and in stricter culling of the decayed tubers the higher prices may have been maintained.

The Lower Rio Grande Valley of Texas is fast cleaning up, expecting to ship 200 to 250 cars the first half of May. The Eagle Lake, Wharton Sugarland section, with 9000 acres, 20 per cent of which are planted with home grown seed, will probably begin shipments about the last week in May, moving 80 per cent of its crop the first half of June. The last week in April this crop was in a very critical stage as it was badly in need of rain. Shipments are expected to total about 1400 cars but if rain does not fall yields may be cut to total about 35 or 40 bushels per acre.

There has been too much rain in Louisiana and Alabama. Normal yields are expected however which may result in the movement of about 2000 cars from Louisiana and 1600–2000 from Alabama.

In South Carolina the acreage planted is near the 5000 mark compared with 9000 last year. The condition of the crop is excellent, with Cobblers in full bloom about April 20. Yields are expected to be very good. Shipment is expected to start about May 15.

Although poor stands are reported from the Mt. Olive and the Aurora sections the prospects are good in North Carolina. In Pamlico County 400 acres were killed to the ground on April 13. The stands in most sections are reported good. Rainfall has been heavy, particularly around Beaufort but no damage is apparent from excessive rains. The weather has been cool and prospects for a crop are fully as good as last year. It is expected that about 600 cars will move beginning May 29 with the peak June 9–16.

The Norfolk, Virginia, section reports a 10 per cent decrease in acreage. Their movement will probably be slightly smaller than last year and will become heavy after North Carolina's peak is passed. On the Eastern Shore of Virginia the stands are reported as good as

in Northampton County. On April 19 most of the plants were up about two inches with many plants in the Cheriton and Kiptopeke sections up four inches. More northern grown seed than usual has been planted on the Eastern Shore. Only half of the acreage was planted before March 15 in Virginia and 15 per cent in Maryland. The remainder was planted the latter part of March and early April. —(A. E. MERCKER, *U. S. Dept. of Agriculture.*)

SECTIONAL NOTES

Wisconsin: Potato growing in Wisconsin is generally associated with diversified farming, especially in the sections where dairying is the basic industry. There will probably be no radical change in the area planted to potatoes this year as compared to the 1932 season. In planning field projects for 1933 we are giving our attention to two prevailing conditions.

First, out of a total of approximately 225,000 acres, approximately 100,000 acres are grown on the lighter soils where season and disease hazards are likely to be relatively severe.

Second, the remaining acreage would classify under the better grades of silt and sandy loams where results as to yield and quality are most likely to be satisfactory.

Obviously, attention to certain field problems becomes urgent both by pressure of the economic situation and by force of other conditions that develop through the changing season conditions. We can go back in our records for example to the relatively cool, wet seasons of 1913, 1914 and 1915 when the most outstanding hazard we faced was the late potato blight epidemic. Then again we might refer to the more normal seasons of 1925, 1926 and 1927 where conditions were more generally favorable. And now we find ourselves checking over the experiences of the 1930, 1931 and 1932 seasons. We have never known a similar period marked by such radical changes as to weather and environmental conditions with resulting fluctuations in yield, quality, disease and insect maladies.

An optimistic phase of the present situation is this, namely, the unusual experience of the past two seasons should aid national and state organizations in concentrating upon major crop and standardization problems. The field projects now taking shape in Wisconsin along these lines are as follows:

In some sections (especially on old, light soil), serious seed difficulties have been encountered affecting germination, stand, etc. In explanation of the trouble, attention has been directed to certain virus maladies. The association of these maladies with high soil temperatures, drought and other seasonal factors has been emphasized. Inferior seed stocks have been detected and are being discarded. In

many cases superior strains have stood up and are replacing inferior stocks.

Attention is centering strongly on scab control. In 1931 and 1932 we noted severe crop losses in soils low in organic matter or generally depleted. This year considerable attention is being given to methods of disinfection, corrective soil handling operations and work with green manuring crops.—J. G. MILWARD, *Agr. Exp. Sta.*

Michigan: Frequent rains and cold weather have delayed the planting of early potatoes which ordinarily in southern Michigan are planted about April 20. It is expected that the potato crop will be reduced to about 224,000 acres which is just equal to the 10-year average. It is believed, however, that some increases in acreage will be planted in areas close to markets. There will also be a marked increase in the plantings made by town and suburban dwellers.

Though prices for the 1932 crop were exceedingly low yet the returns to the growers will probably be better than from the 1931 crop. In fact the 1932 crop was the best in Michigan since 1928. The average yield per acre for 1932 was 116 bushels, compared to 95 for 1931, 63 for 1930 and 71 for 1929.

Total car lot shipments from Michigan up to April 13 were 7,193 compared to 6,793 up to the same date last season. It is difficult, however, to determine accurately the amount of potatoes yet to be shipped, since a large portion of the potato crop in Michigan is trucked to market and no records are kept of the potatoes thus moved. There is a commercial trucking bill now before the Michigan legislature that has as its object the state regulation of trucks that handle produce. The bill would require the trucker to make a complete report each week to the public utilities commission giving date, point of origin and description of each load transported during the week. The public utilities commission in turn would be required to furnish statistics each week to the State Department of Agriculture that would enable that department to make adequate inspection of the produce and to compile accurate figures on the movement of potatoes and other produce by trucks. It is believed by many that such a bill entailing a license fee and a tonnage tax would help the potato marketing situation in Michigan.—H. C. MOORE, *Agr. Exp. Sta.*